Meranie nízkofrekvenčného hluku s dôrazom na sluchové a mimosluchové účinky na človeka
Measuring Low Frequency Noise with Emphasis on Auditory and Non-auditory Effects on Human

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Abstrakt

Nízkofrekvenčný hluk sa stáva významnou výskumnou témou už viac ako osemdesiat rokov. Ako typický hluk, má vplyv nielen na sluchový systém ale taktiež aj na mimosluchový systém človeka, napríklad na kardiovaskulárny systém, môže spôsobovať podráždenie a mať psychosociálne účinky. Tieto účinky môžu byť zdrojom rizika na pracovisku. Meranie a hodnotenie nízkofrekvenčného hluku na pracovisku nie je zahrnuté v platnej smernici Európskeho parlamentu a Rady 2003/10/ES. Cieľom príspevku je porovnanie nameraných hodnôt nízkofrekvenčného hluku v pracovnom prostredí pri operáciách zvárania a brúsenia s rôznymi váhovými filtrami. V diskusii na konci tohto článku sú vyhodnotené namerané hodnoty.

Kľúčové slová

Nízkofrekvenčný hluk, bezpečnosť na pracovisku, riziko, účinky na človeka.

Abstract

Low-frequency noise has been found in many systems and has become a hot research topic for more than eight decades. Like typical noise, it has also effects not only on auditory system (threshold shift) bud also on non-auditory system of human, for example cardiovascular system, annoyance and psychosocial effects. These effects can be the sources of risk at workplace. Measurement and evaluation of low frequency noise in workplace is not included in the valid directive of the European Parliament and Council Directive 2003/10/EC. The aim of the article is a comparison of measured values of low frequency noise in work environment in operations welding and abrasion with different frequency weightings filters. In discussion in the end of this article are values evaluated.

Keywords

Low frequency noise, safety at workplace, risk, effects on human.

Introduction

Sound is a mechanical oscillation that propagates through particles of compressible media. Noise is an unpleasant, unfavourable, annoying or harmful sound to human health, caused by everyday human activities. [1] Low frequency noise is usually defined as a broadband noise with the dominant content of frequencies from 10 (20) to 250 Hz. [2] Low-frequency noise is a common component of occupational and residential noise which has received less attention. However, low-frequency noise has features not shared with noises of higher pitch. [3]

Many cases of noise annoyance deal with noise that has a significant content of low frequencies. The complainants typically describe the noise as "rumbling". Low frequency noise is also in the occupational environments, especially in industrial control rooms and office-like areas. Examples of low frequency noise sources are ventilation systems, pumps, compressors, diesel engines, gas turbine power stations or means of transport, indoor network installations, ventilation, slow-running or idling engines, heating and air conditioning systems. The cases are often solved, either by use of traditional noise limits and measurement methods, or by use of special low-frequency procedures as introduced by some countries, for example Austria, Denmark, Germany, Poland, The Netherlands, Sweden. [2, 4]

Frequency weightings filters in noise measurement

The human ear responds more to frequencies between 500 Hz and 8 kHz and is less sensitive to very low-pitch or high-pitch noises. The frequency weightings used in sound level meters are often related to the response of the human ear, to ensure that the meter is measuring pretty much what you actually hear. It is extremely important that sound level measurements are made using the correct frequency weighting. During the perception of noise distortion occurs, and for this reason weight filters A, B, C, D, G and Z are introduced which are used for the conversion of the actual measured values of noise level to other levels. These filters are inverse to the curves of the equal noise volume at levels of 40 dB, 80 dB and 120 dB, and their frequency sensitivity is similar to the frequency sensitivity of the human ear. [1]

The most common weighting that is used in noise measurement is A-Weighting. Like the human ear, this effectively cuts off the lower and higher frequencies that the average person cannot hear. Although the A-Weighted response is used for most applications, C-Weighting is also available on many sound level meters. C Weighting is usually used for Peak measurements and also in some entertainment noise measurement, where the transmission of bass noise can be a problem. Z-weighting is a flat frequency response of 10 Hz to 20 kHz ±1.5dB. This response replaces the older "Linear" or "Unweighted" responses as these did not define the frequency range over which the meter would be linear. This change was needed as each sound level meter manufacturer could choose their own low and high frequency cut-offs (-3 dB) points, resulting in different readings, especially when peak sound level was being measured. [5]

Auditory and non-auditory effects of low frequency noise

In the field of occupational medicine, several studies claim that low-frequency noise is an agent that interferes with the performance of work tasks and that low-frequency noise can affect mental and physical health. Exposure to noise has harmful effects and constitutes a risk factor for human health. The most cited effects on human health refer to emotional changes, namely agitation, distraction, disappointment, stress, hypertension and the association of low-frequency noise with cognitive impairments, the development of cardiovascular diseases, disturbances in sleep and heart rate and hypertension. Exposure to low-frequency noise has significant impacts on human health. This impact is absorbed by auditory sensation, which is a function of the perception that encompasses aspects of physiological, pathological and sociological order. There are caveats in relating certain harmful effects to a single source of noise, but human exposure to multiple sources of noise must be used as a criterion. [6]

Effects of low-frequency noise on hearing have been examined in terms of permanent loss of auditory acuity permanent threshold shifts and in terms of temporary threshold shift. Laboratory studies of noise at various frequencies show noise-induced changes in blood pressure with vasoconstriction or vasodilation, and heart rate change. The primary, and most frequently reported, perceived effect of low-frequency noise is not that of loudness or noisiness, but that of annoyance. The degree of annoyance or disturbance generated by a specific noise, regardless of frequency, is difficult to predict accurately for individuals. [3]

Some of the symptoms that are related to exposure to low frequency noise such as mental tiredness, lack of concentration and headache related symptoms could be associated with a reduced performance and work satisfaction. [7]

Figure 1 shows the auditory and non-auditory effects of low frequency noise.

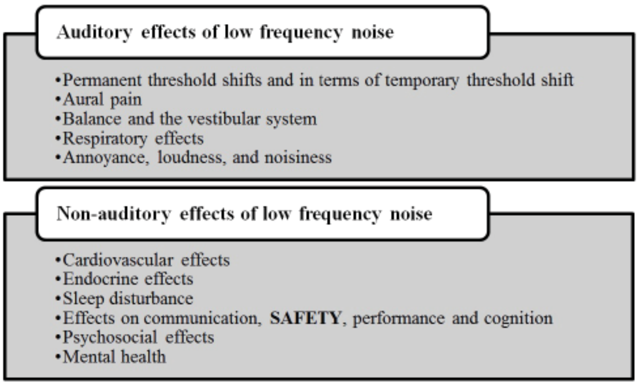

Fig. 1 Effects of low frequency noise on human

Measurement of low-frequency noise on workplace

Measurements are essential for assessing the negative effects of noise and for setting permissible values (criteria) which influence health, comfort and performance in a negative way. Measuring the exposure of employees to noise during work is among the quantitative measurements, and it is done for the purpose of assessing the health-risk of noise exposure and the assigning of a job to a category. An important part of any management of acoustic risks is introducing appropriate criteria for determining a favourable solution to the problems of noise. The required minimizing subsequently determines the resources for making alternative proposals for reducing noise and in the end the resources for estimating costs when meeting the required criteria. [8]

Measurement of low frequency noise exposure was at a workplace, where the production process consists of setting up, welding of the divided and shaped sheet metal into the final product and subsequent abrasion of welds.

The measuring of low frequency noise was performed at the workplace of the equipment operator during operations of welding and abrasion, low frequency noise was measured using a 2250 noise analyser from the company Brüel & Kjær (Fig. 2), which serves for performing broadband measurements of noise exposure in the field. The B&K 2250 host a number of software modules, including frequency analysis, logging (profiling) and recording of the measured signal. [9]

Key features of hand-held Analyzer Type 2250 [9]:

- General-purpose Class 1 sound measurements to the latest national and international standards;
- Occupational noise assessment;
- Environmental noise assessment and logging;
- Product development and quality control;
- FFT analysis of sound and vibration;
- Building acoustics, loudness and noise rating measurements;
- Tone assessment using 1/3-octave and FFT methods;
- Low-frequency building vibration according to ISO 8041:2005 and DIN 45669 - 1:2010 - 09;
- Infrasound (G-weighting) measurements according to ISO 7196:1995 and ANSI S1.42 - 2001 (R2011).

Fig. 2 Hand-held Analyzer Type 2250, module for frequency analysis and time module

The noise meter was placed at a height of 1.5 m above the floor; the axis of the microphone was focused on workplace. The results were stored in the memory of the measuring device and subsequently processed using the relevant computer software. Operator of technical device is not using hearing protectors (Fig. 3).

Fig. 3 Workplace of measurement of low frequency noise

During the experimental measuring the equivalent level A of acoustic pressure L_{Aeq} and the equivalent level Z of acoustic pressure L_{Zeq} were measured over time during the performance of the machining work. The main reason and aim of this measurement was to point out the different levels of acoustic pressure using the A-scale filter and the Z-scale filter at low frequency 100 Hz and at frequency 500 Hz. Records from measurements at various frequencies and weightings are shown in Fig. 4 - Fig. 7.

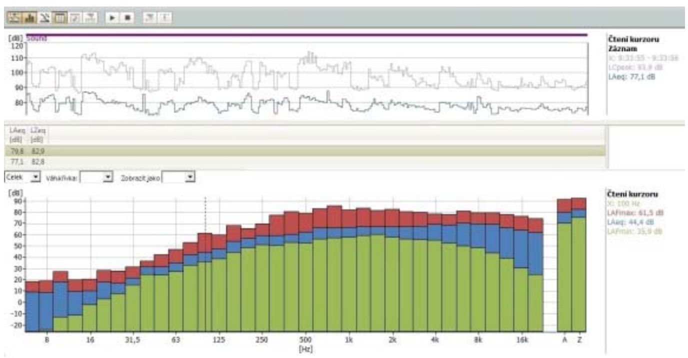

Fig. 4 Record of measurement of noise level A exposure at 100 Hz (welding)

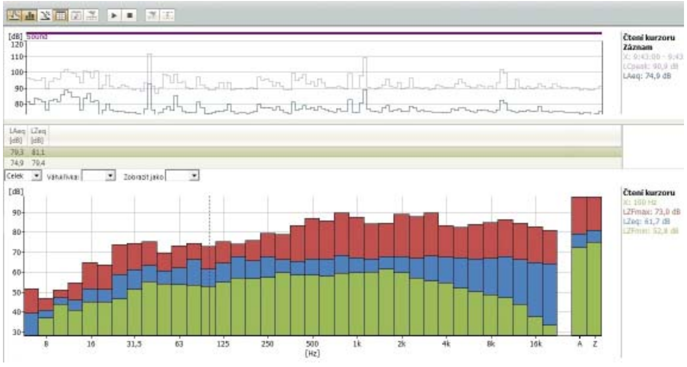

Fig. 5 Record of measurement of noise level Z exposure at 100 Hz (welding)

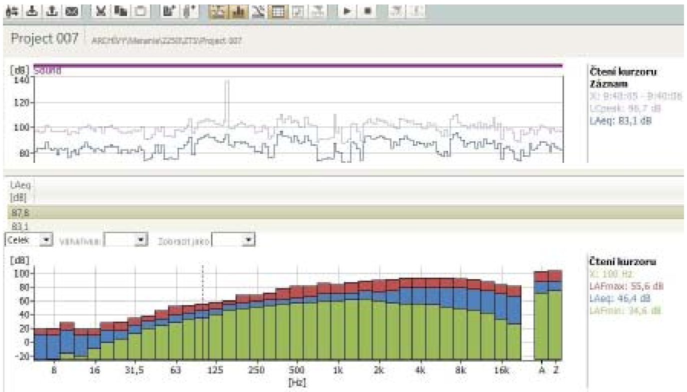

Fig. 6 Record of measurement of noise level A exposure at 100 Hz (abrasion)

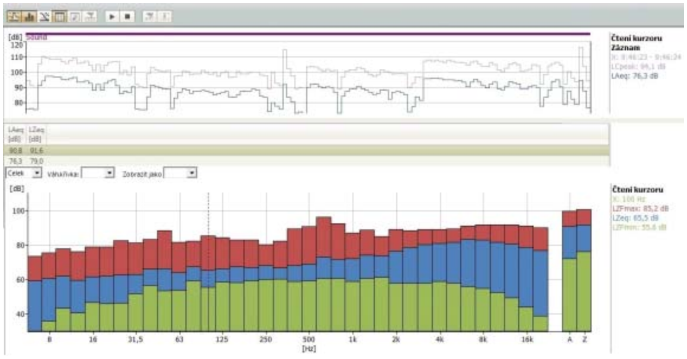

Fig. 7 Record of measurement of noise level Z exposure at 100 Hz (abrasion)

Summary of measured values in operations welding and abrasion with frequency weightings filters A and Z 100 Hz are in Table 1.

Tab. 1 Summary of measured data

Work activities	Value L_{Aeq} at 100 Hz [dB]	Value L_{Zeq} at 100 Hz [dB]
Welding	44,4	61,7
Abrasion	46,4	65,5

Discussion

The measurement of low frequency noise load during welding and abrasion points to the fact that acoustic wavelengths of low frequency (specifically at 100 Hz) have a higher value with weighted Z than with the weighted A, with the difference in values of 17,3 dB in welding and 19,1 dB in abrasion. Such low frequencies are able to influence the cardiovascular system, the neuropsychic system and the sensory-motor functions of a person.

It is impossible from the viewpoint of the working of energy to correctly evaluate the acoustic wavelengths at low frequencies of the A-weighting; therefore, it is more appropriate to use the Z-weighting, or even the C. A small sensitive portion of the population can feel discomfort of very low frequencies (infrasound) even from levels of 65 dB, if the relevant combination of frequency and length of working occur.

Conclusion

At present, when one of the most significant problems is becoming the securing of reliable operation of newly proposed mechanical systems, questions on studying the origin, spread and isolation of low-frequency wavelengths from machines and their parts are very topical. It is possible to ensure the required reduction of the unwanted effects of low-frequency noise on a person and the surrounding environment using vibrodiagnostics and vibroisolation. Because low - frequency noise is a major component of many occupational and community noises, the effects of such noises may be controlled.

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